

AD-A097 125 NAVAL AIR DEVELOPMENT CENTER WARMINSTER PA AIRCRAFT --ETC F/8 11/3

DEVELOPMENT OF A WATER DISPLACING, TOUCH-UP PAINT. (U)

FEB 81 C R HEGEDUS

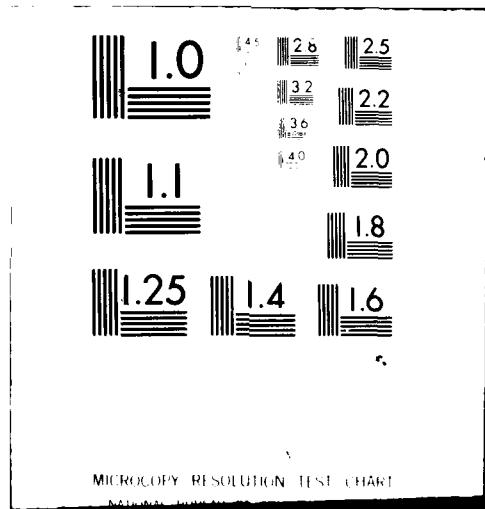
UNCLASSIFIED

NADC-80207-60

NL

| 04 |  
ALFA  
10-1981

END  
DATE  
FORMED  
5-81  
DTIC



AD A 097125

REPORT NO. NADC-80207-60

LEVEL  
12



DEVELOPMENT OF A WATER DISPLACING,  
TOUCH-UP PAINT

Charles R. Hegedus  
Aircraft and Crew Systems Technology Directorate  
NAVAL AIR DEVELOPMENT CENTER  
Warminster, Pennsylvania 18974

24 February 1981

FINAL REPORT  
AIRTASK WF61-562-001  
Work Unit ZM501

STIC  
SELECTED  
APR 28 1981  
S D A

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Prepared for  
NAVAL AIR SYSTEMS COMMAND  
Department of the Navy  
Washington, D. C. 20361

DTIC FILE COPY

81 4 27 114

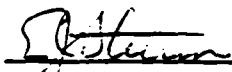
## N O T I C E S

REPORT NUMBERING SYSTEM - The numbering of technical project reports issued by the Naval Air Development Center is arranged for specific identification purposes. Each number consists of the Center acronym, the calendar year in which the number was assigned, the sequence number of the report within the specific calendar year, and the official 2-digit correspondence code of the Command Office or the Functional Directorate responsible for the report. For example: Report No. NADC-78015-20 indicates the fifteenth Center report for the year 1978, and prepared by the Systems Directorate. The numerical codes are as follows:

CODE	OFFICE OR DIRECTORATE
00	Commander, Naval Air Development Center
01	Technical Director, Naval Air Development Center
02	Comptroller
10	Directorate Command Projects
20	Systems Directorate
30	Sensors & Avionics Technology Directorate
40	Communication & Navigation Technology Directorate
50	Software Computer Directorate
60	Aircraft & Crew Systems Technology Directorate
70	Planning Assessment Resources
80	Engineering Support Group

PRODUCT ENDORSEMENT - The discussion or instructions concerning commercial products herein do not constitute an endorsement by the Government nor do they convey or imply the license or right to use such products.

APPROVED BY:



DATE: 2-24-81

E. J. STURM  
CAPT USN

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NADC-80207-60	2. GOVT ACCESSION NO. HD-A097123	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEVELOPMENT OF A WATER DISPLACING, TOUCH-UP PAINT.		5. TYPE OF REPORT & PERIOD COVERED FINAL
7. AUTHOR(s) C R. Hegedus		6. PERFORMING ORG. REPORT NUMBER LF61
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Air Development Center Aircraft and Crew Systems Technology Directorate Warminster, Pennsylvania 18974		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AIRTASK WF61-562-001 Work Unit ZM501
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Department of the Navy Washington, D. C. 20361		12. REPORT DATE 24 February 1981
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		13. NUMBER OF PAGES 31
15. SECURITY CLASS. (of this Report) UNCLASSIFIED		
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE		
16. DISTRIBUTION STATEMENT (of this Report)  Approved for Public Release; Distribution Unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Water Displacing Touch Up Paint Corrosion Preventive		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  A water displacing paint has been developed for touch-up of existing paint which has cracked or chipped. Laboratory results illustrate that this coating has good adhesion, flexibility, and chemical, heat and weather resistances. The coating will displace water from a substrate soon application and will subsequently afford corrosion protection to the underlying metal. The developed coating can be applied by aerosol, conventional or airless spray techniques.		

DD FORM 1 JAN 73 EDITION OF 1 NOV 68 IS OBSOLETE  
S N 0102-E-014-6601INCLASSIFIED  
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

S N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

## S U M M A R Y

## INTRODUCTION

This project was authorized by the Naval Air Systems Command, Washington, D.C. under AIRTASK WF61-562-001, Work Unit ZM501. The objective of the project was to develop a water displacing paint which could be used for touch-up of existing paint on the exterior of aircraft, where this paint has cracked or chipped and moisture is present on or near the damaged area. A water displacing, touch-up paint has to meet the major requirements of the standard coatings for the exterior of naval aircraft; namely MIL-P-23377D, Primer Coating: Epoxy-Polyamide, Chemical and Solvent Resistant and MIL-C-81773C, Coating; Polyurethane, Aliphatic, Weather Resistant. Because of possible shipboard application, the coating would also be required to offer minimal logistics and health hazard problems.

## SUMMARY OF RESULTS

A paint consisting of a silicone alkyd resin, organic solvents, titanium dioxide, zinc molybdate, petroleum sulfonate, and an organo-titanate coupling agent has been formulated. This paint will displace water droplets on a substrate upon application.

The cross-cut adhesion of this coating to 2024-T3 aluminum was measured as 5. This is the highest possible measure obtainable in this test, with possible results ranging from 0 to 5. The parallel-groove test resulted in value of 7 mils at 175 grams. Qualitative empirical relationships provided by the manufacturer of the testing instrument rate this result as excellent adhesion. The scrape adhesion test also indicated a strong coating-aluminum interfacial bond. This test also revealed that the coating is slightly soft after seven days cure but that the coating continues to cure and harden with time. Total curing time is dependent on environmental conditions.

The 1,000 hour 5% NaCl fog test on aluminum panels which were coated and scribed indicated the coating affords good corrosion protection. No blistering, coating uplifting or substrate corrosion occurred during exposure.

Coated specimens resisted 24 hour immersion in hydraulic fluids MIL-H-5606 and MIL-H-83282 at 150°F (66°C). The coatings exhibited no blistering, softening or loss of adhesion after a four hour recovery period following immersion. Similar specimens also resisted 24 hour immersion in MIL-L-23699 lubricating oil at 70°F (21°C). In these fluid immersions, the white paint exhibited slight discoloration, but no more than would be exhibited by the polyurethane topcoat when subjected to similar conditions.

Coated panels subjected to 250°F (122°C) for 20 hours followed by 350°F (179°C) for one hour exhibited no coating defects. The panels were subsequently stripped using the standard Navy paint stripper MIL-R-81294 within three to five minutes.

Coated test specimens were subjected to 500 hours accelerated weathering in a xenon-arc weatherometer. The water displacing paint exhibited no defects. A loss of gloss (60°) from 96 to approximately 65 was observed.

The low temperature bend and room temperature impact tests illustrated that the coating has good flexibility. The coating was bent over a one inch mandrel at -60°F (-51°C) with no cracking or chipping. The impact flexibility of the coating at room temperature was measured as 40% elongation.

The set-to-touch time of the coating when applied to a dry-film thickness of 1.3 mils (33.0 µm) is less than one hour. The dry-hard time is less than nine hours.

#### CONCLUSIONS

1. A pigmented coating has been developed which upon application will displace water from a metal surface.
2. The water displacing paint meets the major physical requirements of, and is compatible with the standard Navy paint system (MIL-C-23377 and MIL-C-81773) and would not have a detrimental effect on the system if used in the fleet for touch-up.
3. It has also been determined that the coating can be applied in an aerosol can or in bulk quantities as a one component paint.

#### RECOMMENDATIONS

1. The developed coating should be extensively field tested as a possible touch-up paint for Navy and Marine aircraft. Because of its water displacing ability, corrosion protection, physical properties, and ease of application, it should prove to be a more efficient touch-up coating than the present material.
2. Further research should be undertaken to thermodynamically and kinetically investigate the phenomenon of water displacement. A parallel effort should be initiated to develop a flat-finish water displacing paint.

## T A B L E   O F   C O N T E N T S

	<u>Page No.</u>
SUMMARY . . . . .	i
Introduction. . . . .	i
Results . . . . .	i
Conclusions . . . . .	ii
Recommendations . . . . .	ii
LIST OF TABLES . . . . .	iv
LIST OF FIGURES . . . . .	v
BACKGROUND. . . . .	1
DEVELOPMENT OF WATER DISPLACING PAINT . . . . .	1
TEST PROCEDURES AND RESULTS . . . . .	2
Adhesion . . . . .	4
Corrosion Resistance . . . . .	9
Salt Fog Exposure . . . . .	9
Fluid Resistance Tests. . . . .	9
Heat Resistance Test. . . . .	12
Accelerated Weather Resistance. . . . .	12
Drying Time . . . . .	13
Flexibility . . . . .	13
Water Displacement Test . . . . .	14
FUTURE CONSIDERATIONS . . . . .	20
REFERENCES . . . . .	20

## L I S T   O F   T A B L E S

<u>Table No.</u>		<u>Page No.</u>
I	Formulation of Water Displacing Paint . . . . .	3
II	Parallel Groove Adhesion Test Empirical Relationships for a Coating of a 1.2 Dry Film Thickness . . . . .	9
III	Tristimulus and LAB Values of Unexposed and Fluid Submerged Specimens using Illuminant C. . . . .	12
IV	Summary of Results. . . . . . . . . . . . . . .	18
V	Comparison of Performance of Water Displacing Paint with Requirements of MIL-P-23377D and MIL-C-81773C. . . .	19

## L I S T   O F   F I G U R E S

<u>Figure No.</u>		<u>Page No.</u>
1	Classification of Cross-Cut Adhesion Test Results. . . . .	5
2	Result of Cross-Cut Adhesion Test of Water Displacing Paint Magnification 10X. . . . .	6
3	Arco Microknife used for Parallel Groove Adhesion Test . . . . .	7
4	Results of Parallel Groove Adhesion Test on Water Displacing Paint Magnification 10X . . . . .	8
5	Results of the Scrape Adhesion Test of Water Displacing Paint . . . . .	10
6	1000 Hours Exposure to 5% NaCl Fog . . . . .	11
7	Water Displacement Test Specimen (AISI 1010 STEEL) at 30° Angle from the Horizontal Liberally Sprayed with Water (Dyed Red) . . . . .	15
8	Water Displacement Test Specimen after Water Displacing Paint has been Applied to Displace Water . . . . .	16
9	Panel A - Only Synthetic Sea Water Applied. Panel B - Synthetic Sea Water Applied followed by Application of the Water Displacing Paint. Photograph Taken after 4 Hours at 100% Humidity . . . . .	17

NADC-80207-60

**BACKGROUND**

Naval aircraft are usually stationed in a marine environment and often subjected to high humidity, sea spray, and severe weather conditions. These are extremely undesirable conditions for maintenance control of these aircraft for two reasons. First, cracked or chipped paint exposes bare metal to the surrounding corrosive environment. Second, when paint touch-up is attempted, moisture on or near the substrate may cause voids in the applied coating. This moisture may also cause the coating to adhere poorly to the substrate.

Maintenance problems caused by moisture on or near a surface which must be treated, prompted the development of two compounds: MIL-C-81309, Corrosion Preventive Compound, Water Displacing, Ultra-thin Film and MIL-C-85054, Corrosion Preventive Compounds, Water Displacing, Clear (AMLGUARD).

These compounds are clear and can be applied quickly and easily in nearly all environments and perform as temporary protective measures against corrosion. Upon application, they displace water which may be present on the substrate. After application, the physical barrier they form and the corrosion inhibitors they contain assist the coating in preventing corrosion of the substrate.

These compounds, however, were developed to remain on the aircraft for a maximum period of sixty days, with subsequent reapplication of the material. Therefore, it was desirable to develop a material with performance characteristics similar to these compounds, but which could also remain on the aircraft for longer periods. This material could be used as a touch-up paint which displaces water on the substrate upon application. The coating would also be required to perform as a corrosion preventive to protect the underlying metal.

Therefore, under AIRTASK WF61-562-001, Work Unit Number ZM501, the Naval Air Development Center was requested to develop a water displacing touch-up paint.

**DEVELOPMENT OF WATER DISPLACING PAINT**

The desired properties of the water displacing paint are as follows. The coating should be a one-component, easily applied paint which will displace water upon application. The resulting coating should also be compatible with the standard Navy coating system; i.e., MIL-P-23377D, Primer Coating: Epoxy-Polyamide, Chemical and Solvent Resistant, and MIL-C-81773C, Coating; Polyurethane, Aliphatic, Weather-Resistant. Finally, the coating should be safe to apply because of ship-board application where there are enclosed areas with minimal ventilation.

The water displacing paint development was comprised of two phases:

1. Investigation of the phenomenon of water displacement to determine how to obtain such a property in a pigmented organic coating.
2. Screening of various polymers as possible binders in this coating.

The first effort revealed a probable mechanism by which an organic coating may displace water from a metal surface.<sup>(1)</sup> This method involves the coating

spreading and completely wetting the substrate upon application. This is accomplished by the coating having a low surface tension (less than 30 dynes per centimeter). The coating must partially adsorb onto the metal surface. At this time, if water droplets are present on the metal surface, the coating can preferentially adsorb and spread under them, thus displacing water from the surface. One criteria is that the coating be immiscible with water so that water cannot be entrapped in the coating after application.

The second effort of the project was to screen various polymers as possible binders for the coating. Reviewing the desired properties narrowed the selection of possible binders to one-component, easily applied, non-toxic resin systems. Physical testing of various binders and a previous investigation<sup>(2)</sup> revealed a silicone-alkyd resin which offers the overall desired properties. This resin provides a binder that has good adhesion, durability, chemical resistance, flexibility, appearance, and ease of application. Also, this resin poses a toxicity problem which is less than that for free isocyanate (polyurethane) resins.

The next step was a coating formulation study. Various solvents, pigments, and additives were evaluated to identify the proper components for the intended use. These materials were incorporated individually in a silicone alkyd system. Solvents were evaluated for solvency, evaporation rates, and ability to displace water, pigments for their hiding power and corrosion inhibition, additives for water displacement, adhesion, and flexibility.

The coating components with the best properties were then combined with the silicone-alkyd binder. The concentration of the various components was then optimized utilizing flexibility, adhesion, corrosion and weather resistance, and water displacement tests. This optimization yielded a coating with the desired properties for the intended use.

Table I lists the coating formulation for a white water displacing, touch-up paint. Paints of various colors can be formulated by decreasing the titanium dioxide concentration and adding the appropriate tinting pigments to obtain the desired color.

#### TEST PROCEDURES AND RESULTS

Unless otherwise stated, all of the test specimens were 2024-T3 bare aluminum alloy meeting Federal Specification QQ-A-250/4. The specimens were cleaned and treated with materials conforming to Military Specification MIL-C-81706 to produce a chemical conversion coating conforming to MIL-C-5541. The dimensions of these test panels were 3X6X0.020 inches (7.62X15.24X0.05 cm).

The water displacing paint was applied directly to the test panels to a dry film thickness of  $1.3 \pm 0.2$  mils ( $33.0 \pm 5.1 \mu\text{m}$ ). This was accomplished by applying one uniform coat, waiting five to 10 minutes, and applying another uniform coat to obtain the desired dry-film thickness. The water displacing paint was allowed to air-dry at  $70^\circ \pm 5^\circ\text{F}$  ( $21^\circ \pm 3^\circ\text{C}$ ) for 7 days before testing.

TABLE I. FORMULATION OF WATER DISPLACING PAINT

	<u>Parts by Weight</u>
Silicone Alkyd Resin <sup>a</sup>	391.0
Ethyl Acetate	194.0
Aromatic Mineral Spirits <sup>b</sup>	117.0
1, 1, 1 Trichlorotrifluoroethane	77.0
Sodium Petroleum Sulfonate <sup>c</sup>	21.0
Rutile; Titanium Dioxide <sup>d</sup>	115.0
Zinc Molybdate <sup>e</sup>	64.0
Isopropyl, Tri(N-ethylamino-ethylamino) Titanate <sup>f</sup> (4.5% in isopropyl alcohol)	21.0
	<hr/>
	1,000.0

- a. McCloskey Varnish Co. (Varkyd 385-50E)
- b. Union Oil of California (Amsco Solvent G)
- c. Alox Corporation (Alox 904)
- d. E. I. DuPont DeNemours and Co. (R-960)
- e. Sherwin Williams Chemicals (Moly-White 101)
- f. Kenrich Chemicals (KR-44S)

Adhesion

Adhesion of the coating to the substrate was tested using three methods: the wet cross-cut method defined in ASTM D3359 method B, the parallel-groove adhesion test and the scrape adhesion test defined in ASTM method D2197, methods A and B respectively.

The wet cross cut test was performed using the Gardner Cross-Cut Apparatus. A coated test specimen was submerged in water at room temperature for 24 hours. The cross-cut instrument was subsequently guided across the specimen using just enough force to have the cutting edges scrape into the substrate, making eleven parallel scribes in the coating. Another set of scribes was made at a 90° angle to the initial scribes to form a grid of 100 square blocks in the coating. A one-inch wide strip of 3M-350 masking tape manufactured by Minnesota Mining and Manufacturing Company was then placed over the blocks using firm pressure. The tape was removed with a quick steady pull. The grid was then inspected and the coating ranked according to the following scale:

- 5B The edges of the cuts are completely smooth; none of the squares of the lattice is detached.
- 4B Small flakes of the coating are detached at intersections; less than 5% of the area is affected.
- 3B Small flakes of the coating are detached along edges and at intersections of cuts. The area affected is 5 to 15% of the lattice.
- 2B The coating has flaked along the edges and on parts of the squares. The area affected is 15 to 35% of the lattice.
- 1B The coating has flaked along the edges of cuts in large ribbons and whole squares have detached. The area affected is 35 to 65% of the lattice.

Figure 1 illustrates examples of test results and respective rankings.

The wet cross cut test was performed on the water displacing paint on five separate panels. The average of these test results is 5. Figure 2 is a representative sample of the performance of the coating in the cross-cut test.

The parallel-groove test was performed using an Arco Microknife manufactured by Gardner Laboratories. Figure 3 is a photograph of this instrument. The instrument makes parallel grooves in a coating which has been applied to a substrate. The distance between the grooves is decreased until a section of the paint between the grooves is lifted or torn from the substrate due to shear stress. At this point, the coating has failed.

The parallel-groove test was performed on the water displacing paint on five separate occasions. The average of these tests according to the ASTM standard is 5.29 adhesion units. Figure 4 is a photograph of a representative result from this test.

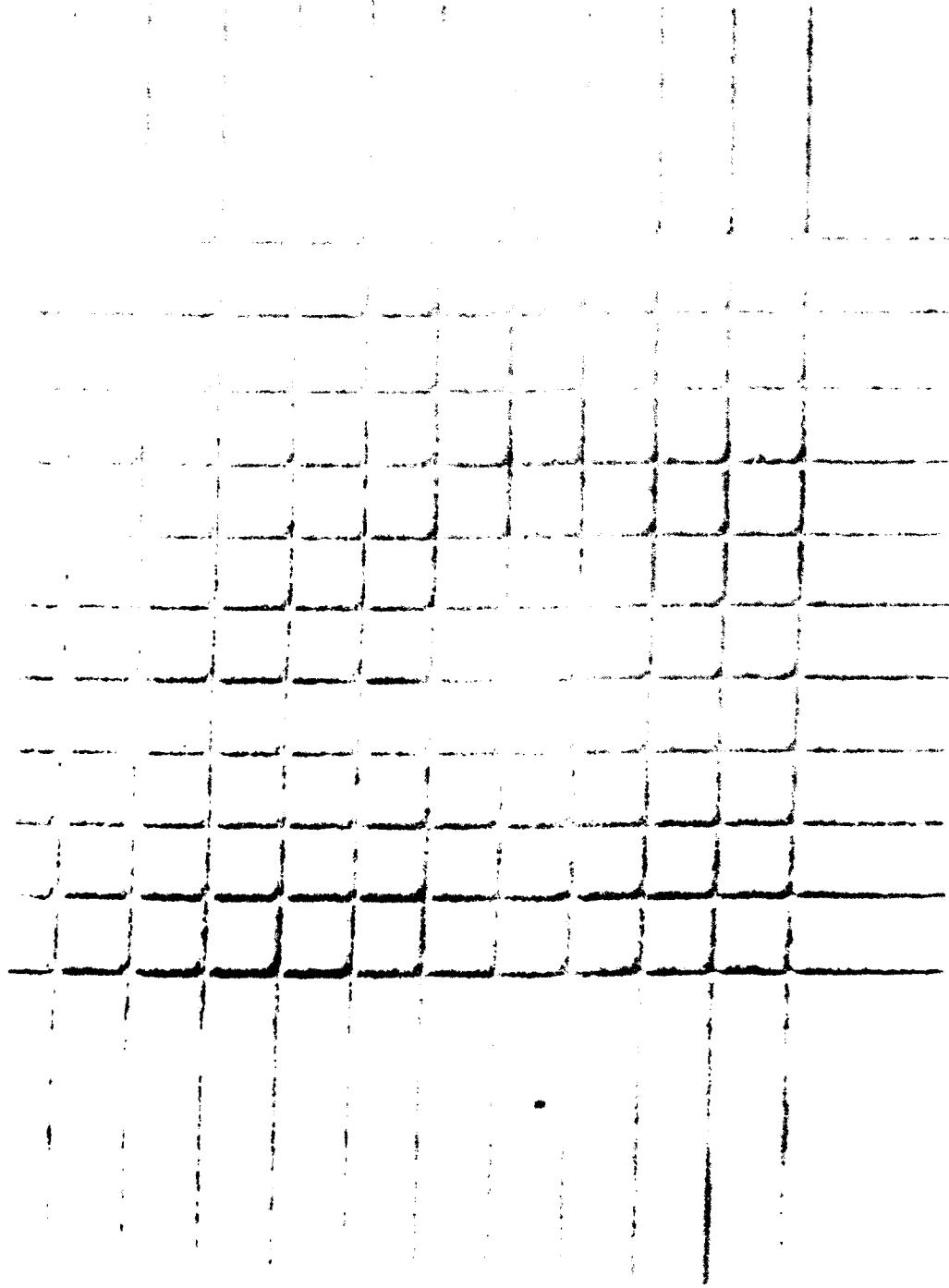
Instructions provided by the manufacturer list empirical relationships which qualitatively rate the adhesion of coatings. Table II lists these ratings with their respective microknife adhesion results. The distance obtained using the

Classification	Surface of cross-cut area from which flaking has occurred (Example for six parallel cuts)
5	None
4	
3	
2	
1	
0	Greater than 65%

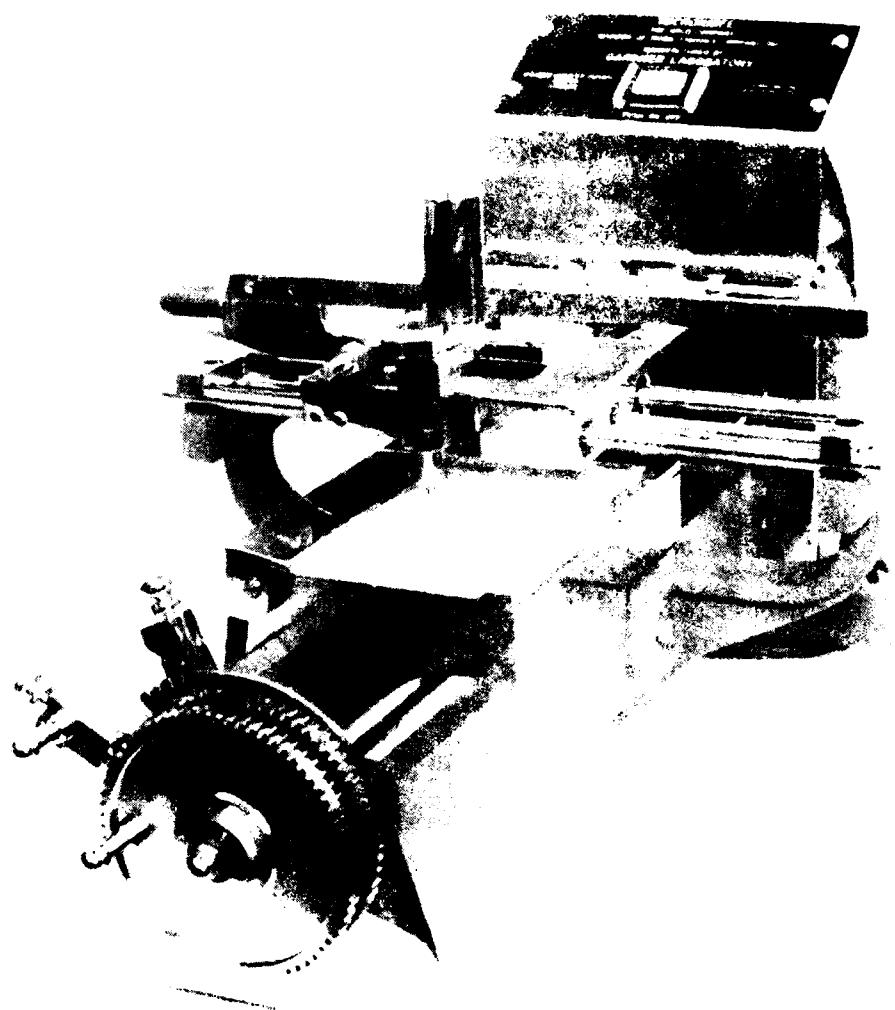
OBTAINED FROM 1979 ANNUAL BOOK OF ASTM STANDARDS, PART 27:  
PAINT - TEST FOR FORMULATED PRODUCTS AND APPLIED COATINGS.

FIGURE 1. CLASSIFICATION OF CROSS-CUT  
ADHESION TEST RESULTS

NADC-3020/-60



NASA - DOVER



**FIGURE 3 ARCO MICROKNIFE USED FOR PARALLEL GROOVE ADHESION TEST**

NADC-80207-60

PAINTED TEST SPECIMEN



FIGURE 4 RESULTS OF PARALLEL GROOVE ADHESION TEST ON WATER DISPLACING PAINT  
MAGNIFICATION 10X

water displacing paint was 7 mils (0.18 mm). This result is illustrated in Figure 4.

TABLE II. PARALLEL-GROOVE ADHESION TEST EMPIRICAL RELATIONSHIPS FOR A COATING OF A 1.2 DRY FILM THICKNESS

<u>Microknife Adhesion</u>	<u>Adhesion Rating</u>
4 to 6 mils	Exceptional
6 to 9 mils	Excellent
9 to 12 mils	Good
12 to 15 mils	Fair
Over 15 mils	Poor

The water displacing paint was subjected to the scrape adhesion test with notable results. The stylus of the test instrument did not scrape through the coating to the substrate at loads up to 10 kilograms. At a load of 1 Kg, the stylus penetrated the surface of the coating. Figure 5 illustrates these results. When tested with the 10 Kg weight, the stylus scraped into the coating but not through to the substrate. When tested with the 1 Kg weight, the stylus again penetrated the coating. This is evidence that the coating is somewhat soft, but may become harder upon full cure. This test indicates that the adhesive strength at the paint-aluminum interface is good and the paint will not be easily removed from the substrate.

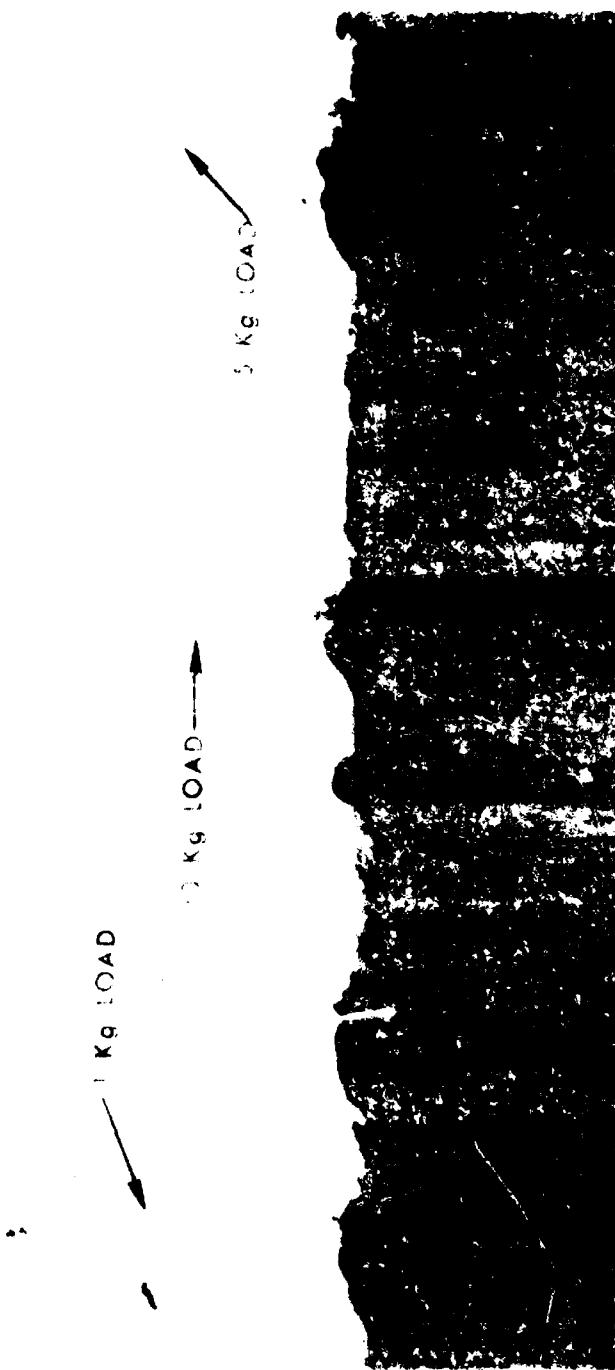
#### Salt Fog Exposure

Coated aluminum panels were scribed with an "X" through the coating into the bare aluminum. These test specimens were placed in a five percent sodium chloride spray cabinet (ASTM B117) for 1000 hours. Examination of the coating and substrate after exposure revealed no blistering or coating uplifting. Stripping of the coating revealed only slight corrosion in the scribe. Figure 6 shows two test specimens after salt spray exposure. The paint has been chemically stripped from Panel B.

#### Fluid Resistance Tests

Painted test specimens were submerged in MIL-H-5606 and MIL-H-83282 hydraulic fluids at 150°F (66°C) for 24 hours. Upon removal of the panels and a recovery period of four hours, the coatings were inspected for any coating defects caused by the fluid environments. The coatings exhibited no blistering, softening, or loss of adhesion, but were slightly discolored. In order to measure this discoloration, colorimetry tests were performed before and after

FIGURE 5 RESULTS OF THE SCRAPE ADHESION TEST OF WATER DISPLACING PAINT.



N4.6 - Spec 2122-60

NADC-80207-60



AFTER PAINT HAS BEEN STRIPPED

A5 REMOVED

FIGURE A5: 10 HOURS EXPOSURE TO 5% NaCl FOG

exposure on a McBeth MC-1010S colorimeter. Table III lists the XYZ tristimulus values as well as LAB values obtained. The two methods for quantifying color are the tristimulus values (XYZ) and the LAB scale.

Painted test specimens were also submerged in MIL-L-23699 lubricating oil at 70°F (21°C) for 24 hours with no coating defects occurring. The slight discoloration which occurred is reflected by the colorimetry values of Table III. Upon exposures at temperatures above 70°F (21°C), the coating irreversibly softens. It is suspected that this is due to the similarity of solubility parameters of the coating and MIL-L-23699.

TABLE III. TRISTIMULUS AND LAB VALUES OF UNEXPOSED AND FLUID SUBMERGED SPECIMENS USING ILLUMINANT C

	<u>Unexposed</u>	<u>MIL-H-5606 at 150°F</u>	<u>MIL-H-83282 at 150°F</u>	<u>MIL-L-23699 at 70°F</u>
X	81.74	75.94	79.21	79.83
Y	84.93	75.98	81.48	81.65
Z	89.81	76.93	82.50	81.69
L	92.16	87.17	90.27	90.36
A	-2.95	2.98	-1.34	-0.44
B	6.75	8.70	9.02	9.67

#### Heat Resistance Test

Painted test specimens were subjected to a temperature of 250°F (122°C) for 20 hours, followed by one hour at 350°F (179°C). The coating exhibited no blistering, checking, loss of adhesion or other defects. The coating was subsequently stripped with the standard paint stripper, MIL-R-81294, to determine if stripping would be a problem after elevated temperature exposure. The coating was capable of being stripped within three to five minutes.

#### Accelerated Weather Resistance

Painted test specimens were exposed for 500 hours in a 6000 watt xenon-arc weatherometer. The cycle consisted of 18 minutes of high intensity light and water spray followed by 102 minutes exposure solely to the high intensity light. The specimens were tested according to ASTM method G26, Type BF with the conditions in the chamber as follows:

Black body temperature	$140^{\circ} \pm 5^{\circ}\text{F}$ ( $60^{\circ} \pm 3^{\circ}\text{C}$ )
Relative humidity	$50 \pm 5\%$
Intensity of xenon arc	0.5 to 0.6 watts per square meter at 340 nanometers wavelength

After 500 hours exposure, the coatings exhibited no blistering, uplifting, or loss of adhesion. Of the five specimens tested, the average  $60^{\circ}$  gloss of the coatings according to ASTM method D523 was 65.6 with a standard deviation of 3.7. The average  $60^{\circ}$  gloss before exposure was 96.

#### Drying Time

The water displacing paint was applied to aluminum panels. One uniform coat of paint was applied to the aluminum substrate. After five minutes, another uniform coat was applied. The intended dry-film thickness was  $1.3 \pm 0.2$  mils ( $33.0 \pm 5.1 \mu\text{m}$ ). The coated panels were then allowed to cure in laboratory conditions with a room temperature of  $70 \pm 5^{\circ}\text{F}$  ( $21 \pm 3^{\circ}\text{C}$ ) and relative humidity of  $50 \pm 5\%$ . The set-to-touch and dry hard times were less than one hour and less than nine hours, respectively, when tested as specified in ASTM method D1640.

#### Flexibility

Aluminum alloy test panels,  $3 \times 6 \times 0.020$  inches ( $7.62 \times 15.24 \times 0.05$  cm) in dimension, conforming to QQ-A-250/4 (0 temper) were anodized in accordance with MIL-A-8625, Type I. These panels were coated with the water displacing paint to a dry film thickness of  $1.3 \pm 0.2$  mils ( $33.0 \pm 5.1 \mu\text{m}$ ). After curing for seven days, the panels were tested according to ASTM D1737 which specifies bending around a one-inch mandrel at a temperature of  $-60 \pm 5^{\circ}\text{F}$  ( $51 \pm 3^{\circ}\text{C}$ ). After returning to room temperature the coating was examined for cracking along the bend. The coatings on all five specimens tested were intact with no cracking or separation from the substrate.

Similar test specimens were prepared and tested for impact flexibility as defined in Method 6226 of the Federal Test Method Standard 141. The test instrument consists of a solid steel cylinder with spherical knobs protruding from the ends. These knobs are designed such that elongations of 1/2, 1, 2, 5, 10, 20, 40, and 60 percent can be tested. The steel cylinder falls freely through a hollow guide cylinder and strikes the reverse side of a coated panel. The imprints formed from the knobs are then examined for cracking. The imprint with the highest elongation which does not exhibit cracking is recorded as the impact flexibility.

Five painted specimens were tested as described. All five exhibited 40% elongation with no cracking or chipping of the coating.

Water Displacement Test

Steel test specimens conforming to AISI 1010 of MIL-S-7952 with dimensions of 2 x 4 x 0.125 inches (50 x 101 x 3.18 mm) were used in this test.

The test panels were set at a 30° angle from the horizontal with one of the two inch ends raised. A panel is then liberally sprayed with red dyed synthetic sea water\* so that fine droplets completely cover the panel. Figure 7 illustrates a specimen after water has been applied. Subsequent to the water application, one milliliter of the paint is poured along the upper edge of the specimen using a pipette, followed by another milliliter one minute later. After being suspended vertically for one minute, the panel is placed horizontally, painted side up, in a closed desiccator at  $70 \pm 5^{\circ}\text{F}$  ( $21 \pm 3^{\circ}\text{C}$ ) and 100% static relative humidity.

After four hours in the desiccator, the surface is examined for possible water entrapment. The coating is then removed from the substrate by wiping with a cloth dampened with methyl ethyl ketone. The bare steel is then examined for signs of corrosion caused by synthetic sea water remaining on the surface.

Figure 8 illustrates a water displacement test specimen five minutes after the displacing paint was applied. The coating is uniform with no indication of water on the specimen.

Figure 9 compares a control specimen (only synthetic sea water applied) to a specimen which was treated with the water displacing paint. Figures 8 and 9 depict the effectiveness of the paint as a water displacing agent.

Table IV summarizes the tests performed on the water displacing paint along with the results. Table V compares the performance of the paint with the requirements of MIL-P-23377D and MIL-C-81773C. The newly developed paint meets the major physical requirements of both specifications.

\* Synthetic sea water solution: 50 grams of sodium chloride, 22 grams of magnesium chloride, 3.2 grams of calcium chloride, and 8.0 grams of sodium sulfate in 1.0 liter of distilled water.

NADC-80207-60



FIGURE 7 WATER DISPLACEMENT TEST SPECIMEN (AISI 1010 STEEL AT 10° ANGLE FROM THE HORIZONTAL LIBERALLY SPRAYED WITH WATER DYED RED)

NADC-80207-60



**FIGURE 8 WATER DISPLACEMENT TEST SPECIMEN AFTER WATER DISPLACING PAINT HAS BEEN APPLIED TO DISPLACE WATER**

NADC-86-207-60

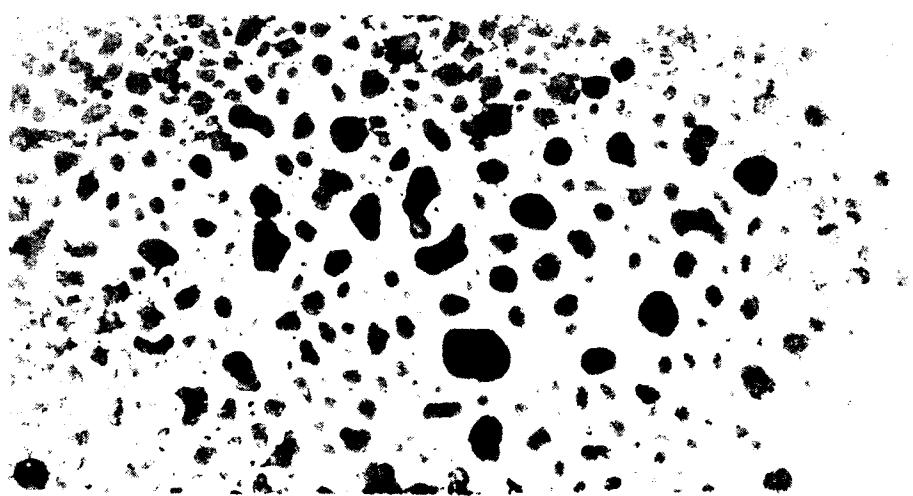


PLATE A: DENSITY SINTERING OF A WATER APPLIED POREY SYNTHETIC SEA WATER APPLIED  
TO FOLLOWING THE APPLICATION OF A 10% CATION EXCHANGER, PHOTOGRAPH TAKEN AFTER  
4 HOURS AT 100°C IN AIR.

TABLE IV. SUMMARY OF RESULTS

<u>Test</u>	<u>Method</u>	<u>Result</u>
Cross cut adhesion	ASTM D 3359 Method B	5
Parallel groove adhesion	ASTM D 2197 Method A	5.29
Scrape adhesion	ASTM D 2197 Method B	10 Kg
Corrosion resistance	ASTM B 117 1000 hrs.	No blistering or up-lifting of coating. No substrate corrosion.
Accelerated weathering	ASTM G26 Type BF (500 hrs)	No coating defects, slight gloss reduction.
Dry hard time	ASTM D 1640	Less than 9 hours.
1 inch mandrel flexibility	ASTM D 1737 at -60°F	No cracking or uplifting.
Impact flexibility	FTMS I41 Method 6226	40% elongation
Water displacement	MIL-C-85054	Pass: no corrosion
MIL-H-5606 and MIL-H-83282 immersion	24 hours at 150°F	Pass: no coating defects, slight discoloration.
MIL-L-23699 immersion	24 hours at 70°F	Pass: no coating defects, slight discoloration.
Heat resistance	20 hours at 250°F 1 hour at 350°F	No coating defects, slight discoloration

TABLE V. COMPARISON OF PERFORMANCE OF WATER DISPLACING PAINT  
WITH REQUIREMENTS OF MIL-P-23377D AND MIL-C-81773C

<u>Specification</u>	<u>Test</u>	<u>Requirement</u>	<u>WDP Test Result</u>
MIL-P-23377D	Tape adhesion FTMS 141 Method 6301.1	No uplifting	Pass
MIL-P-23377D	Corrosion resistance ASTM B 117	1000 hrs No blistering. No substrate corrosion.	Pass
MIL-C-81773C	Ambient flexibility FTMS 141 Method 6226	40% Elongation (no cracking)	Pass
MIL-C-81773C	-60° F flexibility ASTM D 1737	1 inch mandrel (no cracking)	Pass
MIL-C-81773C	MIL-H-5606 24 hr. immersion at 150° F	No defects	Pass
MIL-C-81773C	MIL-H-83282 24 hr. immersion at 150° F	No defects	Pass
MIL-C-81773C	Accelerated weather resistance ASTM G 26, Type BH	500 hrs. No cracking or crazing 60° gloss ≥ 80	No cracking or crazing 60° gloss = 65
MIL-C-81773C	Heat resistance 20 hrs. at 250° F 1 hr. at 350° F	No film degradation	Pass

R E C O M M E N D A T I O N S

During this project, only highly reflective gloss finishes were formulated because of the current requirements of Navy coatings on aircraft. In the future, low reflective flat finishes will be used on military aircraft to reduce detectability during combat missions. It is suggested that investigations of a flat water displacing paint be initiated. It is suspected that this may pose a problem. Coatings which produce a flat finish contain high concentrations of pigments relative to glossy paints. This introduces large amounts of solid particles which must be coated with the vehicle. It is suspected that the additional surface area will interfere with the ability of the coating to displace water. This is suggested because of the complex interaction between water displacing coatings and solid surfaces. It is, therefore, recommended that the development of a flat water displacing paint be investigated.

It was also observed during the extensive literature search of this project that there are no quantitative tests for the displacement of water via organic compounds. All of the available tests are qualitative which give little indication of the comparative performance of water displacing agents. An effort should be initiated to develop such a quantitative test for water displacement.

R E F E R E N C E S

- (a) C. R. Hegedus, "Water Displacing Corrosion Preventive Compounds", presented at Lehigh University Corrosion Control by Coatings Conference, Aug 1980.
- (b) G. J. Pilla, "The Development of Amlguard, a Clear, Water Displacing, Corrosion Preventive Compound", NAVAIRDEVCE Report No. NADC-78220-60, May 1979.

DISTRIBUTION LIST

REPORT NO. NADC-80207-60

AIRTASK NO. WF61-562-001  
Work Unit No. ZM501

**DATE:  
ILME**